Appendix N. Emission Factors for Steam and Chilled/Hot Water

Emission Factors for Steam and Chilled/Hot Water for Emissions Inventories

Use the emission factors in the following table to calculate indirect emissions from the consumption of purchased steam and hot/chilled water for emissions inventories.

Energy Product	Carbon Dioxide	Methane	Nitrous Oxide
Steam or Hot Water			
Units of Measure	kg/MMBtu	g/MMBtu	g/MMBtu
Value [a]	88.18	8.169	0.603
Chilled Water			
Units of Measure	kg/ton-hours cooling	g/ton-hours cooling	g/ton-hours cooling
Absorption Chiller Using Natural Gas [b]	0.884	0.083	0.002
Engine-Driven Chiller Using Natural Gas [b]	0.590	0.056	0.001
Electric-Driven Chiller [b]			
Units of Measure	kg/ton-hours cooling	g/ton-hours cooling	g/ton-hours cooling
Domestic			
1999-2002 [c]	0.629	0.017	0.010
1991-1994 [c]	0.639	0.019	0.011
Foreign	See Note 2 below	See Note 2 below	See Note 2 below

[a] Weighted average based on Energy Information Administration's (EIA) 1998 Manufacturers Energy Consumption Survey data on the quantities of natural gas, coal, and residual and distillate fuel oils consumed as boiler fuel, emission factors from Appendix H of these instructions, and EIA/OIAF efficiency assumptions of 80, 81, and 82 percent for natural gas, coal and petroleum boilers, respectively. Factors also assume 10 percent losses during transmission.
[b] Chilled water efficiencies based on California Climate Action Registry, *General Reporting Protocol* (October 2002). Factors also assume 10 percent losses during transmission.
[c] Use 1999-2002 factors to calculate emissions and reductions for Start Year reports for 2002 or later and Reporting Year reports for 2003 or later. Use 1991-1994 factors to calculate emissions and reductions for Start Year reports for 1990 through 2001 and Reporting Year reports for 1991 through 2002. Factors also assume 10 percent losses during transmission.

Emission Factors for Steam and Chilled/Hot Water for Emission Reductions

Use the emission factors in the table below to calculate the following:
- Avoided emissions resulting from the sale of steam and hot/chilled water to another entity.
- Reductions in indirect emissions resulting from the consumption of purchased steam and hot/chilled water.

Energy Product	Avoided Emissions From Energy Sales	Reductions in Indirect Emissions From Purchased Energy
Steam or Hot Water (kg CO_2e/MMBtu)	79.71 [a]	88.57 [b]
Chilled Water (kg CO_2e/ton-hours cooling)		
Absorption Chiller Using Natural Gas [c]		0.884
Engine-Driven Chiller Using Natural Gas [c]		0.590
Electric-Driven Chiller [c]		
Domestic		
1999-2002 [d]	0.754 [e]	0.892
1991-1994 [d]	0.754 [e]	0.918
Foreign	See note 2 below	See note 2 below

[a] Weighted average based on Energy Information Administration's (EIA) 1998 Manufacturers Energy Consumption Survey data on the quantities of natural gas, coal, and residual and distillate fuel oils consumed as boiler fuel, emission factors from Appendix H of

U.S. Department of Energy
Energy Information Administration
Form EIA-1605   Voluntary Reporting of Greenhouse Gases

Form Approved
OMB No. 1905-0194
Expiration Date: 10/31/2013

these instructions, and EIA/OIAF efficiency assumptions of 80, 81, and 82 percent for natural gas, coal and petroleum boilers, respectively.
[b] Same methodology as avoided emission reductions factors but includes 10 percent losses during transmission.
[c] Chilled water efficiencies based on California Climate Action Registry, *General Reporting Protocol* (October 2002).
[d] Use 1999-2002 factors to calculate emissions and reductions for Start Year reports for 2002 or later and Reporting Year reports for 2003 or later. Use 1991-1994 factors to calculate emissions and reductions for Start Year reports for 1990 through 2001 and Reporting Year reports for 1991 through 2002.
[e] All avoided emission reductions are assumed to displace chilled water from electric driven chillers.
Source: U.S. Department of Energy, Office of Policy and International Affairs, *Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006) p. 154-156.

Note 1 – Calculation Methods

<u>Steam or Hot Water Emission Factors</u>

Steam and hot water emission factors were calculated using the following equations:

$$EF_{Inventories} = EF_f * CE * 1/(1-TL)$$
$$EF_{Reductions} = EF_f * CE * 1/(1-TL)$$
$$EF_{Avoided\ Emissions} = EF_f * CE$$

Where:

$EF_{Inventories}$	=	**Emission factor for emissions inventories (kg CO_2/MMBtu, g CH_4/MMBtu, or g N_2O/MMBtu)**
$EF_{Reductions}$	=	**Emission factor for emission reductions (kg CO_2e/MMBtu)**
$EF_{Avoided\ Emissions}$	=	**Emission factor for avoided emissions (kg CO_2e/MMBtu)**
EF_f	=	**Emission factor for boiler fuel used (kg CO_2/MMBtu, kg CO_2e/MMBtu, g CH_4/MMBtu, or g N_2O/MMBtu)**
CE	=	**Conversion efficiency of boiler (percent)**
TL	=	**Transmission losses (percent)**

<u>Chilled Water Emission Factors</u>

Emission factors for chilled water from absorption or engine-driven chillers were calculated using the following equations:

$$EF_{Inventories} = EF_f * ECF * COP * 1/(1-TL)$$
$$EF_{Reduction} = EF_f * ECF * COP * 1/(1-TL)$$
$$EF_{Avoided\ Emissions} = EF_f * ECF * COP$$

Where:

$EF_{Inventories}$	=	**Emission factor for emissions inventories (kg CO_2/ton hour cooling, g CH_4/ton hour cooling, or g N_2O/ton hour cooling)**
$EF_{Reductions}$	=	**Emission factor for emission reductions (kg CO_2e/ton hour cooling)**
$EF_{Avoided\ Emissions}$	=	**Emission factor for avoided emissions (kg CO_2e/ton hour cooling)**
EF_f	=	**Emission factor for boiler fuel used (kg CO_2/MMBtu, kg CO_2e/MMBtu, g CH_4/MMBtu, or g N_2O/MMBtu)**
ECF	=	**Energy conversion factor (9.7024×10^{-4} MMBtu/ton hours cooling)**
COP	=	**Coefficient of performance (dimensionless)**
TL	=	**Transmission losses (percent)**

Emission factors for chilled water from electric-driven chillers were calculated using the following equations:

U.S. Department of Energy
Energy Information Administration
Form EIA-1605

Voluntary Reporting of Greenhouse Gases

Form Approved
OMB No. 1905-0194
Expiration Date: 10/31/2013

$$EF_{Inventories} = EF_{ei} * ECF * COP * 1/(1-TL)$$
$$EF_{Reduction} = EF_{er} * ECF * COP * 1/(1-TL)$$
$$EF_{Avoided\ Emissions} = EF_{ea} * ECF * COP$$

Where:

$EF_{Inventories}$	=	Emission factor for emissions inventories (kg CO_2/ton hour cooling, g CH_4/ton hour cooling, or g N_2O/ton hour cooling)
$EF_{Reductions}$	=	Emission factor for emission reductions (kg CO_2e/ton hour cooling)
$EF_{Avoided\ Emissions}$	=	Emission factor for avoided emissions (kg CO_2e/ton hour cooling)
EF_{ei}	=	U.S. average or regional or national foreign emission factor for electricity for emission inventories (metric tons CO_2/MWh, kg CH_4/MWh, or kg N_2O/MWh)[12]
EF_{er}	=	U.S. average or regional or national foreign emission factor for electricity for emission reductions (metric tons CO_2e/MWh)[13]
EF_{ea}	=	U.S. average or regional or national foreign emission factor for electricity for avoided emissions (metric tons CO_2e/MWh)[14]
ECF	=	Energy conversion factor (3.51685×10^{-3} MWh/ton hours cooling)
COP	=	Coefficient of performance (dimensionless)
TL	=	Transmission losses (percent)

Note 2 – Electric Driven Chiller Emission Factors for Foreign Countries

For emissions and emission reductions associated with electric-driven chillers in foreign countries, reporters should calculate emission factors using the regional or national foreign electricity emission factors in Appendix F. Use the formulas provided below, which are based on the methods described in Note 1 above, to calculate appropriate emission factors (kg/ton-hour cooling).

Chilled Water Emission Factor for Use in Calculating Indirect Emissions for Emission Inventories

Reporters should use the following formula for calculating appropriate CO_2, CH_4, and N_2O emissions factors for use in estimating indirect emissions for emissions inventories:

$$EF_{Chilled\ Water} = 0.921 * EF_{Electric/Inventory}$$

Where:

$EF_{Chilled\ Water}$	=	Emissions factor, expressed in kg CO_2/ton hour, g CH_4/ton hour, or g N_2O/ton hour of cooling purchased
$EF_{Electric/Inventory}$	=	Appropriate regional or national electricity emissions factor for emission inventory from Appendix F, expressed in MT CO_2/MWh, kg CH_4/ton hour, or kg N_2O/ton hour of cooling purchased

The resulting emission factors assume 10 percent losses during transmission. Calculate separate emission factors for CO_2, CH_4, and N_2O.

---

[12] Electricity emission factors were taken from Appendix F of the instructions to Form EIA-1605 and multiplied by 1000 to convert the units from metric tons per MWh to kilograms per MWh for carbon dioxide and from kilograms per MWh to grams per MWh for methane and nitrous oxide.

[13] Electricity emission factors were taken from Appendix F of the instructions to Form EIA-1605 and multiplied by 1000 to convert the units from metric tons CO_2e per MWh to kilograms CO_2e per MWh.

[14] Electricity emission factors were taken from Appendix F of the instructions to Form EIA-1605 and multiplied by 1000 to convert the units from metric tons CO_2e per MWh to kilograms CO_2e per MWh.

U.S. Department of Energy
Energy Information Administration
Form EIA-1605

Voluntary Reporting of Greenhouse Gases

Form Approved
OMB No. 1905-0194
Expiration Date: 10/31/2013

Chilled Water Emission Factor for Use in Calculating Reductions in Indirect Emission Reductions

Reporters should use the following formula for calculating an appropriate emissions factor for use in estimating reductions in indirect emission associated with purchased chilled water:

$$EF_{Chilled\ Water} = 0.921 * EF_{Electric/Indirect}$$

Where:

$EF_{Chilled\ Water}$	=	Emissions factor, expressed in kg CO_2e/ton hour of cooling purchased
$EF_{Electric/Indirect}$	=	Appropriate regional electricity emissions factor for indirect emission reductions from Appendix F, expressed in MT CO_2e/MWh.

The resulting emission factors assume 10 percent losses during transmission.

Chilled Water Emission Factor for Use in Calculating Avoided Emissions

Reporters should use the following formula for calculating an appropriate emissions factor for use in estimating avoided emissions associated with the sale of chilled water produced by electric-driven chillers to other entities:

$$EF_{Chilled\ Water} = 0.837 * EF_{Electric/Indirect}$$

Where:

$EF_{Chilled\ Water}$	=	Emissions factor, expressed in kg CO_2e/ton hour of cooling purchased
$EF_{Electric/Indirect}$	=	Appropriate regional or national emission electricity emissions factor for indirect emission reductions from Appendix F, expressed in MT CO_2e/MWh.

The resulting emission factor assumes no losses during transmission.